ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. 38 - THE MILITARY CHARACTERISTICS AND DESIGN OF OBSERVATION TELESCOPE

Project No. 38

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1 May 1945

ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 38
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1 May 1945

MILITARY CHARACTERISTICS AND DESIGN
OF OBSERVATION TELESCOPE

1. PROJECT: No. 38 - Report on the Military Characteristics and Design of Observation Telescope.

a. Authority - First Indorsement by Office of The Surgeon General to Letter, Headquarters, Army Ground Forces, 4 May 1944, File No. 413.7-1 (Fort Knox) N SPMDO.

b. Purpose - To develop the Military characteristics of observation telescopes and present designs of proposed types of instruments to meet these characteristics.

2. a. DISCUSSION:

(1) The basic requirement for this instrument is to provide optimal vision for detecting enemy targets and for laying fire upon the enemy; primary employment is to be by Artillery; secondarily, to be employed by other Ground Force units.

(2) No unanimity of opinion can be obtained as to what constitutes optimal vision.

(3) The demand for high power is universal, the requested magnification commonly ranging from 20 to 40 power.

(4) The demand for great light gathering power is also widespread. A minimum of 6 mm exit pupil is indicated.

(5) The requirements for adequate field of view are commonly ignored and little information can be gathered on this point.

b. Desired characteristics, other than optical, which are frequently mentioned, are:

(1) Light weight

(2) Compactness

(3) Ruggedness

(4) Vertical periscopic offset for the protection of the observer.

(5) Provision of directional information in azimuth and elevation, together with the magnetic bearing.

(6) Elevation range high enough to permit observation of air burst.

(7) Scale accuracy of 1/10 mil desirable, and 1/4 mil mandatory.

c. Other characteristics not commonly mentioned, but of great importance to optimal vision, must also be considered. These are:

(1) Stereo perception. Most binoculars suffer from the fact that magnification of image is greater than of depth perception. In penetrating camouflage and detecting the presence of enemy, doubtless stereo perception would be a major advantage.

(2) Adequacy of field. Its great importance is seldom realized and should be a serious consideration in limiting magnification.

(3) The undesirability of excessive magnification with its consequent losses in field, stability, ruggedness and lightness and its greater requirement of accuracy of parallelism is not given sufficient weight in reaching a proper compromise. Atmospheric conditions commonly limit the advantage gained by increasing power to an effective magnification of 10 or 15 times, further magnification yielding no improvement in detail seen.

d. All these requirements taken together are obviously unattainable; hence a compromise and choice of the most important features must be made, with special attention to practicability of production.

e. In view of all the foregoing considerations and the experience gained from a study of artillery requirements and practice, the desirable military characteristics may be summarized as follows:

(1) Power - 15 to 18 times (possibly 20).

(2) Field - 3.5° minimum, 5° desirable.

(3) Exit pupil - 6 mm minimum, 7 mm desirable.

(4) Relative aperture - f/3.6 acceptable, f/4 desirable.

(5) Air-glass surfaces, half coated throughout.

(6) Reflections - internal throughout if possible.

(7) Azimuth and elevation scales -
   (a) Spiral mask type in order to avoid 100 mil errors.
   (b) At least every other mil numbered.
   (c) Internally viewed, if possible.

(8) Compass for magnetic bearing - larger and more accurate than on aiming circle.

(9) Elevation range - 300 mils depression to 700 mils elevation.

(10) Azimuth movement - slow worm motion with throw-out for quick orientation.

(11) Compactness - greatest attainable, with tripod housing the instrument if possible, thus permitting a single parcel for carrying.

(12) Weight - minimum compatible with ruggedness.

(13) Direction of view, either:

(a) Horizontal with periscopic offset, or
(b) 30 to 45° downward, if no offset, thus permitting a short tripod and direct command of the terrain by simply raising the eyes.

(14) Provision for stopping down objective when the light intensity is high.

(15) Provision of low power finder - three or four times with wide field desirable.

f. Certain difficulties arise in the design of an optimal observation instrument, as follows:

(1) Weight is bound to be greater than desirable and hence must be minimized by the employment of the lightest possible materials and a careful consideration of the structural thicknesses.

(2) The attainment of adequate parallelism of axis must be a primary consideration throughout.

(3) Adequate stereo perception and periscopic offset cannot be provided in the same instrument without complete sacrifice of compactness of form.

(4) Experience with such high powered binoculars is so limited that the construction of alternative forms for field test is strongly urged.

g. As a result of an extensive analysis, it is felt that a requirement exists for three distinct types of instruments:

(1) A full stereo binocular, meeting the most exacting optical requirements but of relatively great size and weight, intended only for limited distribution and use.

(2) A general utility binocular of more conservative design, providing good stereo vision; instrument easily enclosed in a short tripod for carrying.

(3) A periscopic binocular with limited stereo base, but otherwise having optimal properties, to be employed at the most forward observation posts where subject to heavy fire.

h. The three proposed instruments are described more fully in Appendices I, II and III.

3. CONCLUSIONS:

a. Features popularly demanded in an optimal observation binocular are conflicting and unobtainable as a whole, so that compromise designs must be considered.

b. Experience with high powered binoculars is so limited as to justify the construction for test of at least 3 alternative compromise forms which promise to meet many of the urgent needs.

4. RECOMMENDATIONS:

That instruments of the three types for which military characteristics and preliminary layouts are furnished in the Appendices be constructed and submitted to field test.

Submitted by:
Frederick S. Brackett, Lt. Col., SnC

APPROVED Willard Machle
WILLARD MACHLE
Colonel, Medical Corps
Commanding

4 Incls:
#1 - Appendix I
#2 - Appendix II
#3 - Appendix III
#4 - Figures 1 thru 7

APPENDIX I

FULL STEREO BINOCULAR
18 to 20 Power - 124 mm Objective Diameter

1. General

This instrument (Figs. 1 and 2) is proposed primarily to determine the value of full stereo perception in the detection of concealed enemy positions. Compactness and lightness are seriously compromised in this instrument. Periscopic offset is not possible. Because of the great moment of inertia and wind resistance of the instrument, provision is made for the use of a short rugged tripod by choice of a convenient 30° downward direction of view.

2. Military Characteristics of Optical System

a. Power - 18 times (power may be increased to 20 times by provision of a shorter focus eyepiece)

b. True field - 4° (3.6° for 20 power)

c. Objective diameter clear - 124 mm

d. Exit pupil - 6.9 mm (6.2 mm for 20 power)

e. Objective-equivalent focal length, - 446 mm (f/3.6 relative aperature)

f. Eyepiece-equivalent focal length, - 24.8 mm (22.3 mm for 20 power)

g. Stereo base - 1 meter (approximately 18 times I.P.D.)

3. Military Characteristics of Structure.

a. Two arms of the optical system carried in a single rigid external shell. The front-surfaced end mirrors are rigidly mounted in this shell.

b. Interpupillary adjustment accomplished by symmetrically displacing both optical trains with the exception of the end mirrors.

c. Elevational parallelism secured by dowels 4¼ inches apart, contained in the mirror heads.

d. A 30° downward view is provided, thus permitting the observer to glance readily over the instrument at the terrain.

e. A 4 power, wide field monocular finder is placed to the right of the right ocular, also with a 30° downward direction of vision.

f. Scales for both azimuth and elevation are of the spiral mask type with numbers every other mil; this design has been shown largely to eliminate 100 mil and other errors in reading.

Incl. #1

g. Eye cups to be unsymmetrical and of thin rubber, formed to fit the eye socket and forehead contour and thus provide a light seal with minimum pressure. NOTE: Headrests are undesirable on tripod mounted instruments (in contrast to instruments rigidly mounted in a tank or hand-held), since the pressure neccessary to make a headrest effective is sufficient to disturb a tripod support.

h. Great compactness has been secured with respect to end-on dimensions in order to permit the enclosure of the instrument within its own tripod (as suggested in Fig. 5) or within a box of minimum cross section.

i. The central mounting head provides compass, levelling vials, azimuth worm and gear, free azimuthal adjustment and clamp for magnetic orientation and three point levelling screws. Scales, vials and needle observation are conveniently arranged for the observer's vantage point. Controls for the major motions are arranged for right hand manipulation.

j. The instrument may be converted to a stereo range finder with illuminated markings especially disposed for sensing fire, by attachment of an autocollimating optical bar.

k. Hinged flaps cover the windows for protection when closed and to serve as sun and sky shades when open.

l. A second hinged flap on each window with a central opening reduces the exit pupil to 5 mm when closed or leaves full aperture when opened with the cover flap. Reduced aperture will markedly improve vision at high light levels.

APPENDIX II

MEDIUM STEREO BINOCULARS
15 Power - 100 mm Objective Diameter

1. General

In order to provide an instrument of greater general usefulness than the full stereo binoculars described in Appendix I but one which still retains the chief advantages of the larger instrument, the more conservative design shown in Figs. 3 and 4 is suggested.

2. Military Characteristics of Optical System

a. Power - 15 times

b. True Field - 4.8°

c. Objective diameter - 100 mm (f/3.8 relative aperture)

d. Exit pupil - 6.6 mm

e. Objective - equivalent focal length, 380 mm

f. Eyepiece - equivalent focal length, 25.4 mm

g. Stereo base - 60 cm (approximately 10 times I.P.D.)

3. Military Characteristics of Structure

a. Telescopes of unitary construction.

b. Interpupillary adjustment by displacing the left hand telescope.

c. Elevational parallelism secured by paralleling rod 3-5/8" from the common axis.

d. 30° downward view.

e. Four (4) power, wide field finder, mounted on right hand telescope.

f. Scales and eyecup, same as in Appendix I.

g. Compactness such that a short rugged tripod can house instrument as a carrying case (Fig. 5). Overall length 28 inches.

h. Central mounting head, similar to that shown in Appendix I.

i. Lens cover, sun shade and diaphragm, as in Appendix I.

Incl. #2

4. Comparison

a. The power selected will provide all useful magnification over a wide range of atmospheric conditions and makes possible a twenty per cent greater field of view than is available in the proposed full stereo binocular.

b. The reduction in aperture not only makes for reduction in weight but also insures better definition.

c. The three per cent reduction in Exit Pupil will reduce the night effectiveness less than one per cent.

d. The base of 10x I.P.D. yields approximately a 12½ times stereo advantage for depth perception, or 83% of the linear magnification.

e. Compared to the present 19.5 x 54 observation telescope T133, this instrument will give:

(1) 50% greater effectiveness in night operation.

(2) Over twice the depth perception.

(3) Over twice the field of view.

(4) Greater compactness and a single convenient parcel to carry.

(5) More accurate scales and a means of obtaining a compass bearing.

(6) More rugged support and far less trouble with image motion.

APPENDIX III

PERISCOPIC BINOCULARS
18 - 20 Power - 126 mm Objective Diameter

1. General

The need of periscopic offset for protection of the observer when operating from foxholes or behind masonry walls under heavy enemy fire makes the consideration of a third type desirable. This instrument (Figs. 6 and 7) sacrifices stereo base in order to secure other advantages. Not only is a 7½ inch periscopic offset obtained, but the instrument can operate through an opening 12 inches wide. Internal reflection has been secured without use of prisms of excessive size. Internally viewed scales are provided. Greater ruggedness is also obtained.

2. Military Characteristics of Optical System

a. Power - 18x (20x with a shorter focus eyepiece)

b. True Field - 4° (3.6° for 20 power)

c. Objective diameter - 126 mm

d. Exit pupil - 7 mm (6.3 for 20x)

e. Objective - equivalent focal length, 480 mm (f/3.8)

f. Eyepiece - equivalent focal length, 26.7 mm (24 mm for 20x)

g. Stereo base - 16.5 cm (about 2.5 times I.P.D.)

3. Military Characteristics of Structure

a. Telescopes of unitary construction.

b. Interpupillary adjustment by rotation of left hand telescope around axially parallel hinge.

c. Parallelism by conventional hinge.

d. Direction of view same as direction of target.

e. Finder may be mounted between telescopes, probably of lens erecting type, with periscopic offset to bring the eye position just above one of the main oculars.

f. Scales of spiral mask type but brought into the right telescope field at the top for direct, in-telescope reading.

g. Eyecups - same as in Appendix I.

h. Cover and diaphragm mounted on sleeve-type shade. Cover when open may be oriented for best sun protection. Sleeve may be extended for most adverse conditions.

i. Compactness is a primary consideration. The entire instrument is contained in a volume 12" x 12" x 12½", thus making the carrying box small despite large lenses, great focal length and complete mounting head.

4. Comparison.

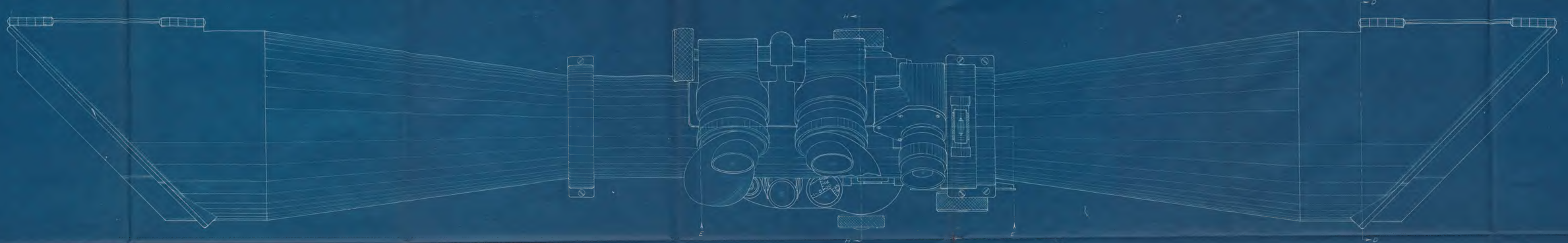
a. The stereo advantage has been reduced to about 7x compared with 12½x and 18x in the other forms.

b. In all other ways, this instrument is optically optimal.

c. A conservative periscopic offset has been chosen (7½") in order to use 3" upper prisms. It is thought that most of the desired protection has been obtained except when used in poorly formed foxholes where a higher advantage point may be required.

d. The short periscopic offset also makes possible a well-balanced instrument and avoids many of the objections to the older BC scope.

e. The axes have been located to secure an elevation range of 1000 mils (700 above horizontal) and good instrument balance.



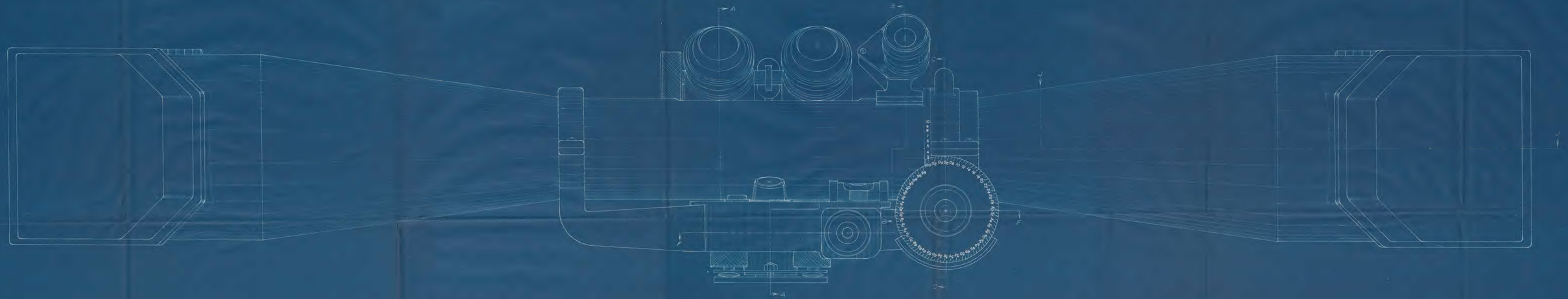


FIG. 1

FULL STEREO BINOCULARS 18 TO 20 POWER 124 MM OBJECTIVE DIAMETER
ARMORED MEDICAL RESEARCH LABORATORY FORT KNOX, KENTUCKY
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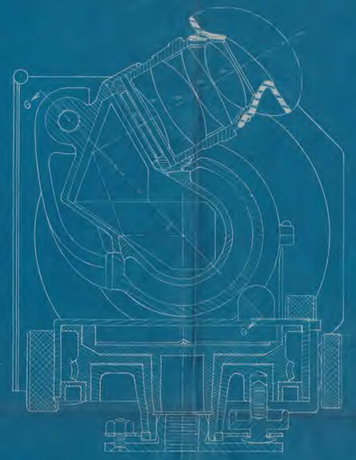
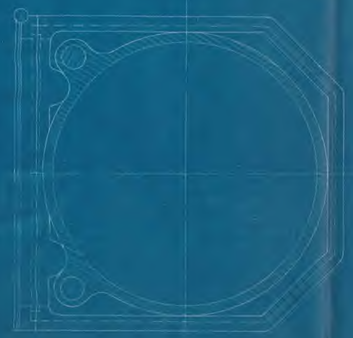
SCALE FULL SIZE | DATE



Section A-A



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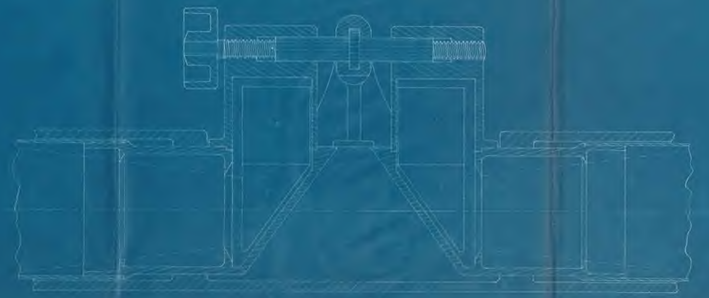
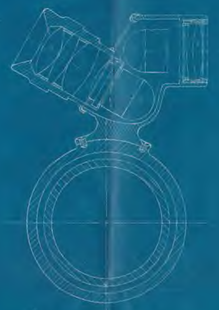


Section G-G

Section H-H



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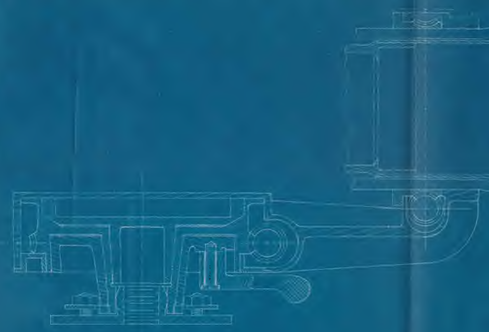

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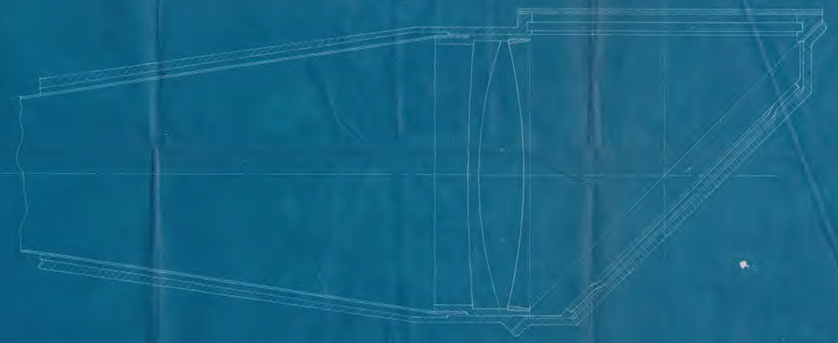
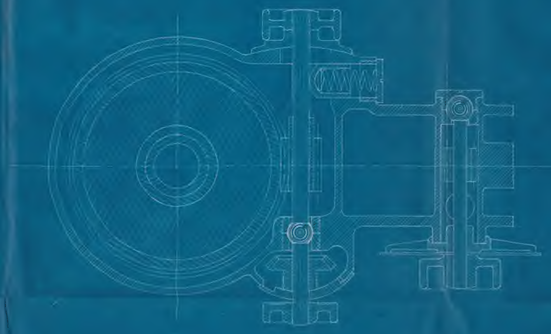


Section J-J

Section C-C



Section F-F

FIG. 2

FULL STEREO BINOCULARS 18 TO 30 POWER 124 MM OBJECTIVE DIAMETER CONSTRUCTION DETAILS	
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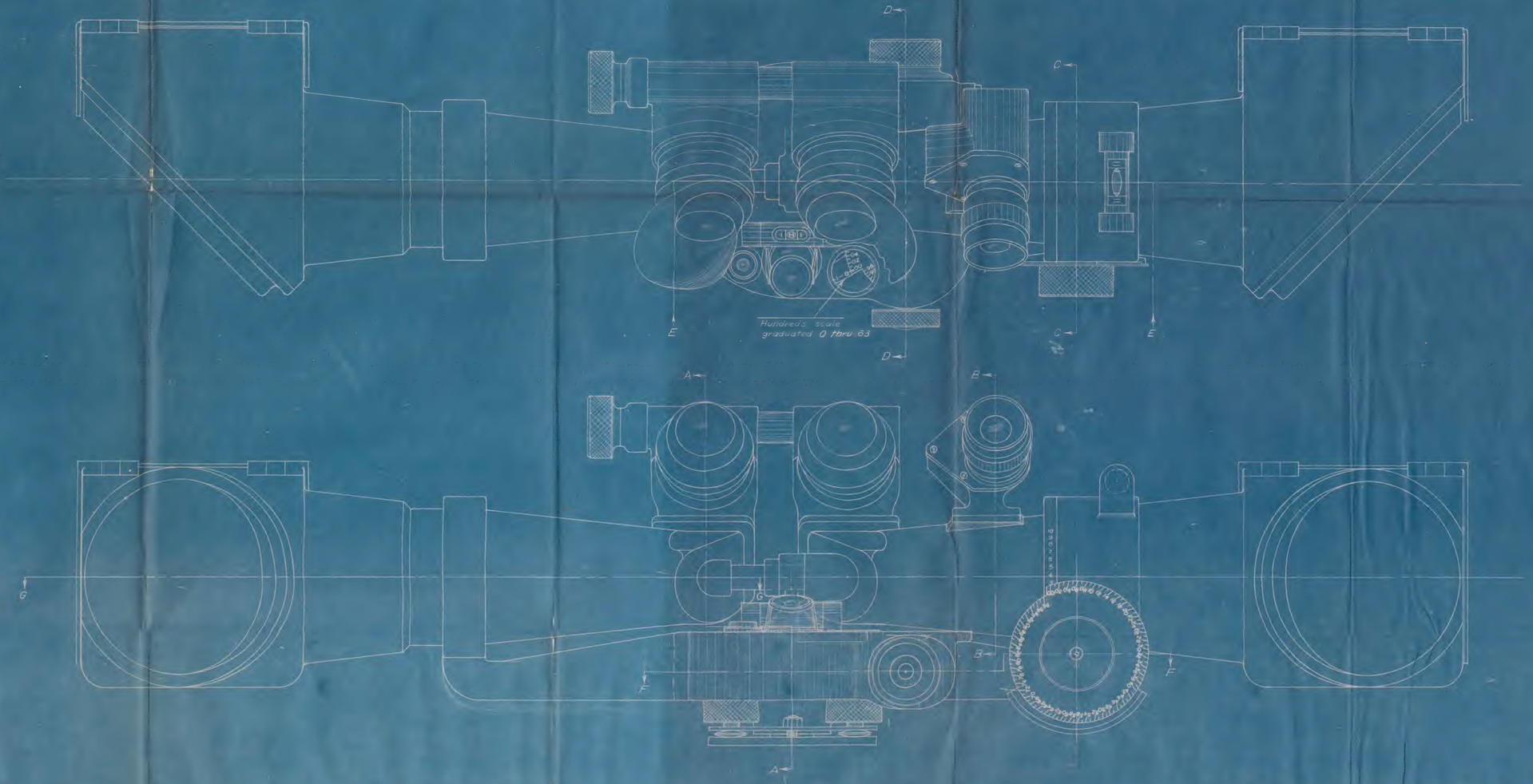

FIG. 3

MEDIUM STEREO BINOCULARS (80 cm BASE) 15 POWER - 100 MM. OBJECTIVE DIAMETER
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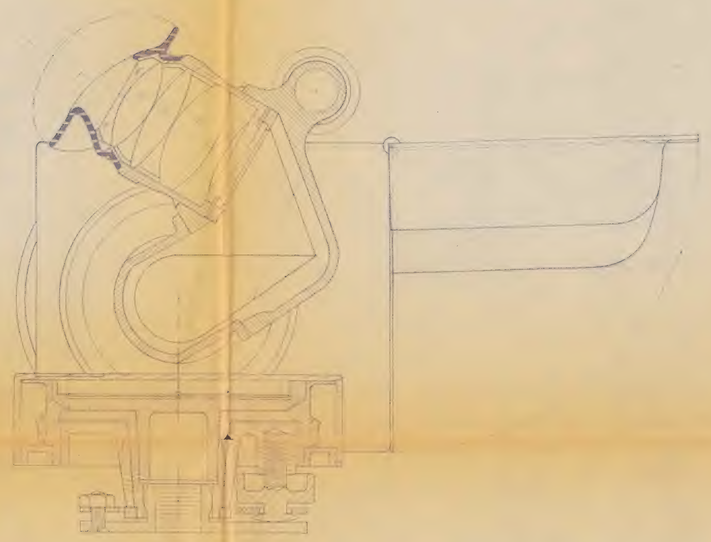

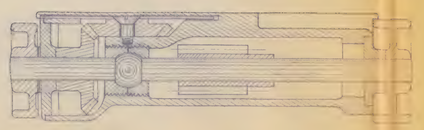

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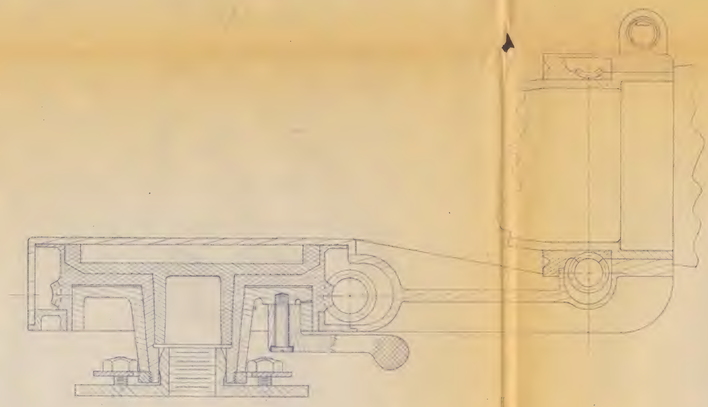

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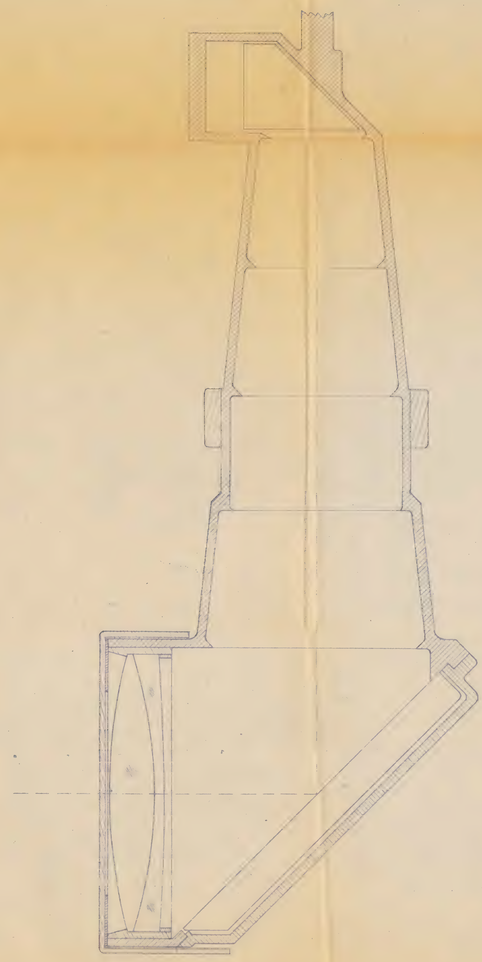

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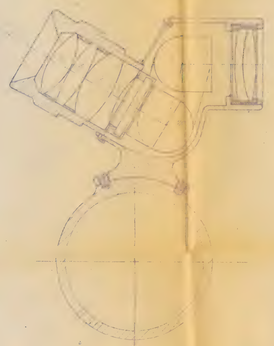

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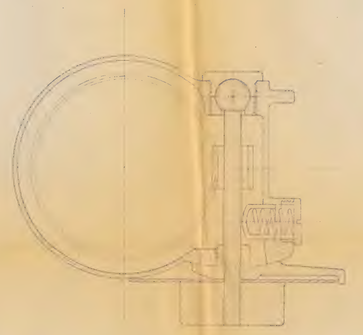

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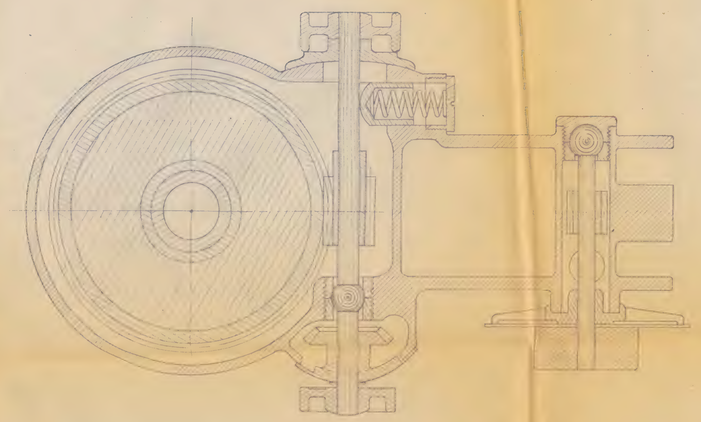

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FIG. 4

MEDIUM STEREO BINOCULARS CONSTRUCTION DETAILS
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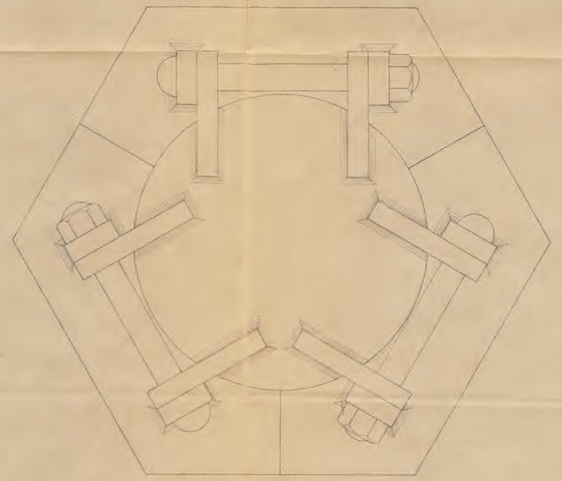

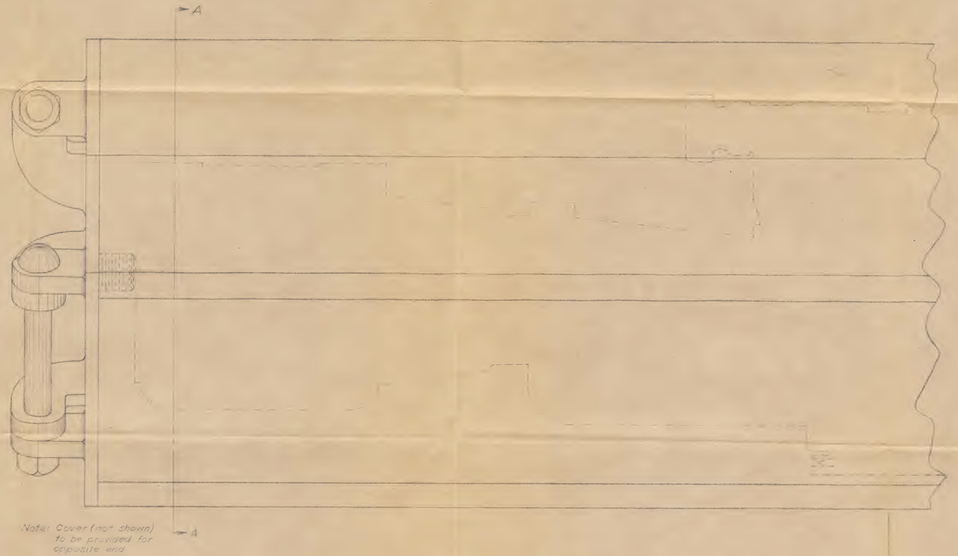

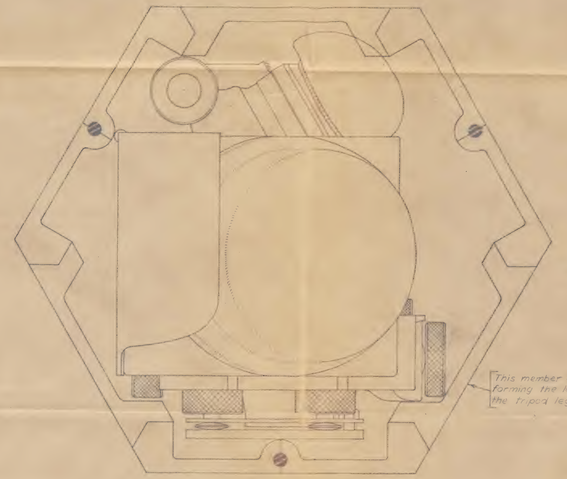

Section A-A

FIG. 5

COMBINATION TRIPOD AND CARRYING CASE FOR MEDIUM STEREO BINOCULARS
(Suggested design only; not shown in detail)

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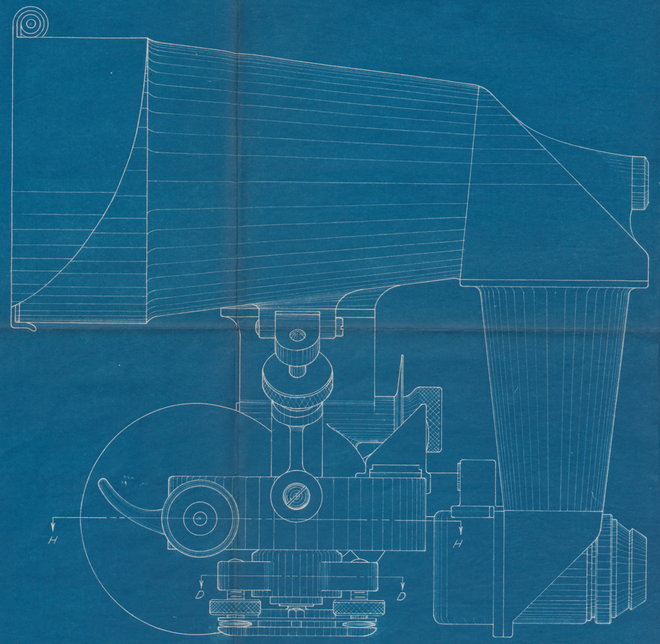

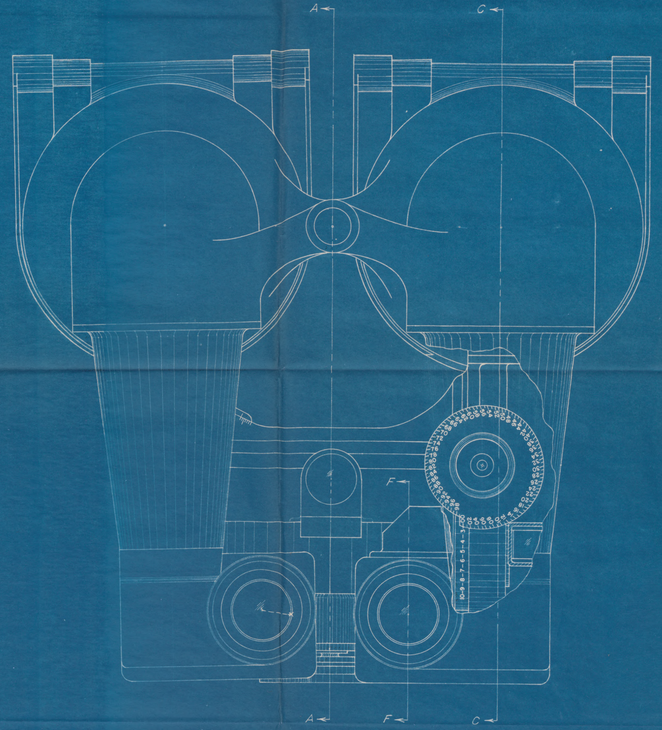

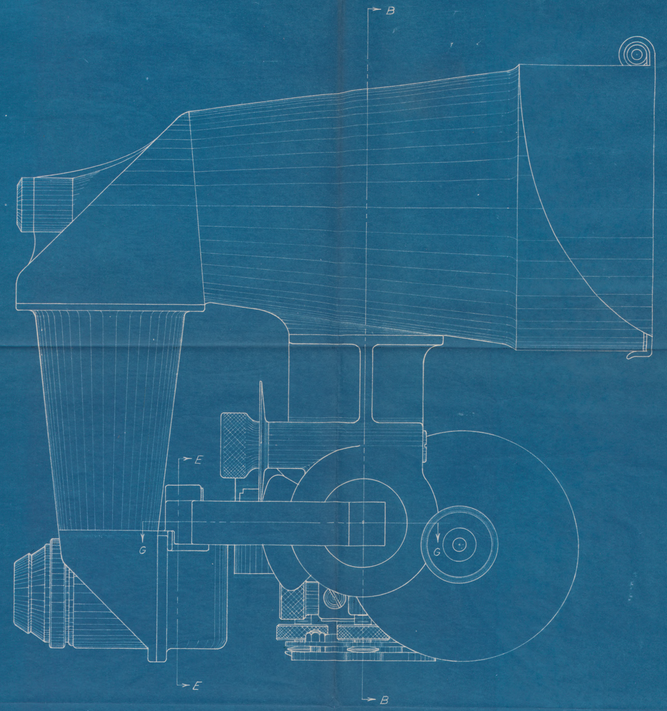

FIG. 6

PERISCOPIC BINOCULARS 18-20 POWER - 126 MM. OBJECTIVE DIAMETER	
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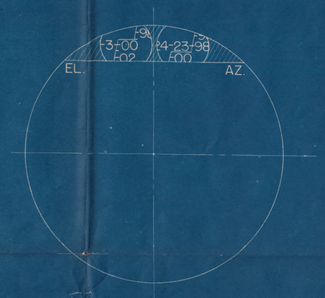
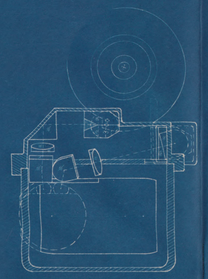


Note:
Illustrating "in telescope" presentation of scale readings (right telescope)

Section D-D



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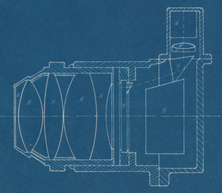

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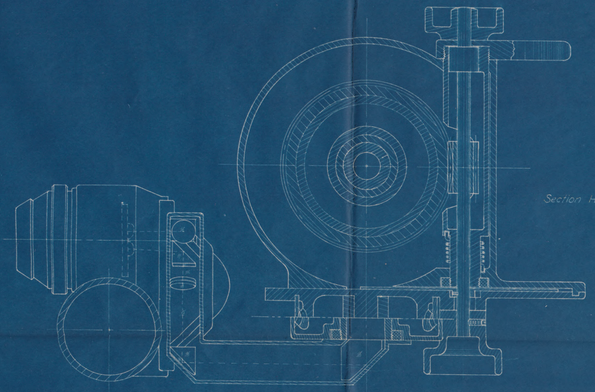

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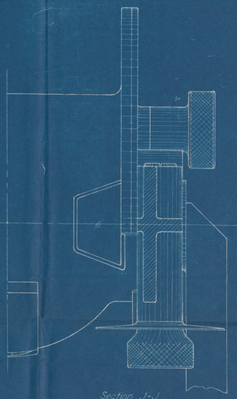
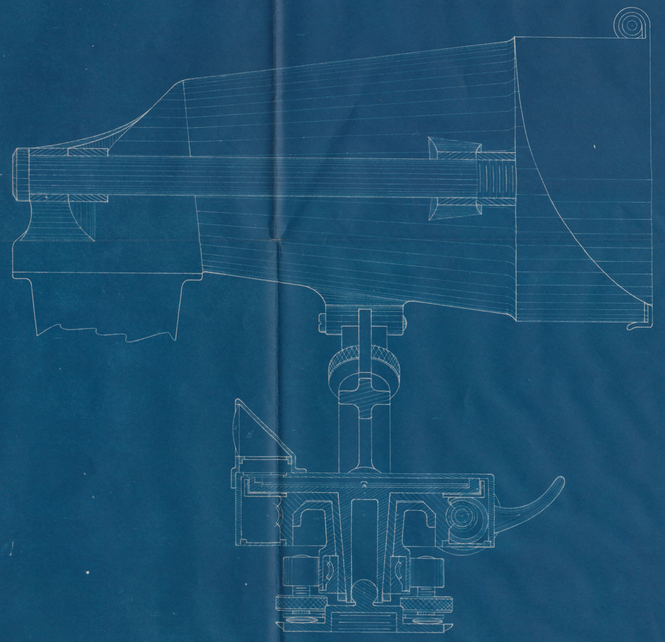
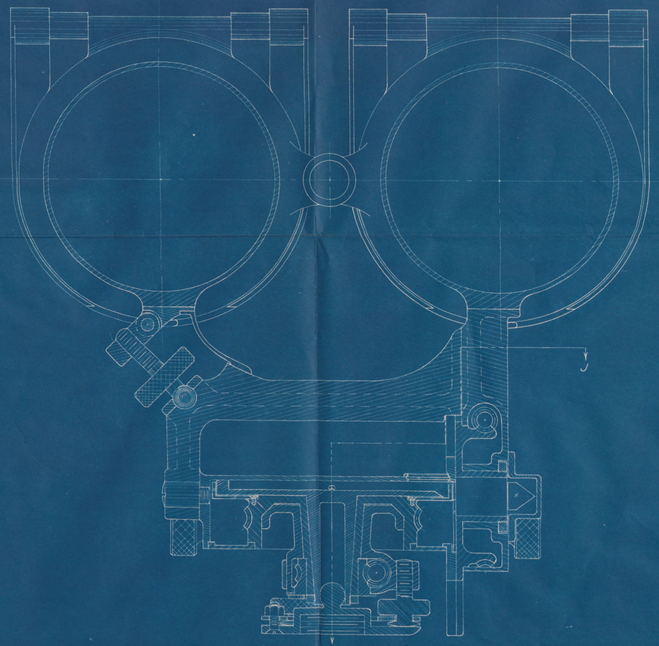


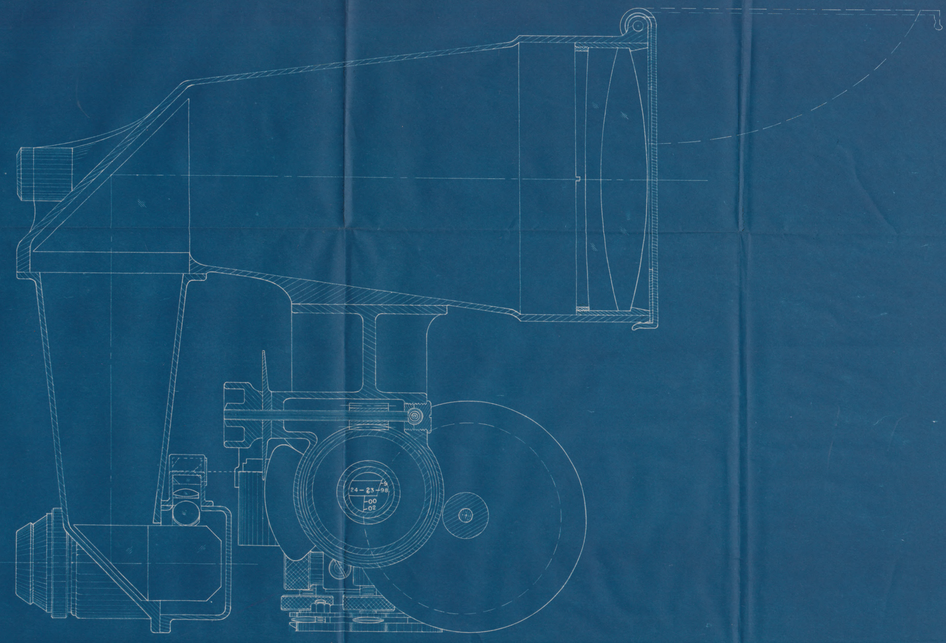
Section J-J



Section A-A



Section B-B



Section C-C

FIG. 7

PERISCOPIC BINOCULARS CONSTRUCTION DETAILS	
ARMORED MEDICAL RESEARCH LABORATORY FORT KNOX, KENTUCKY	
Lt. Col. P. S. Brackett	
SCALE FULL SIZE	DATE